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Monitoring and modelling distributed water storage to understand local gravity at Moxa, Germany

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Dedecting change in water storage from associated temporal variability in terrestrial gravity has become an important topic for hydrologists. Since the GRACE satellite mission has been launched in March 2002 the understanding of the effect of hydrology on terrestrial gravity has substantially increased. Most studies so far focussed on quantification of large-scale and low temporal resolution (e.g. continental and monthly time scale) water storage change from the GRACE gravity fields. Few studies report on deriving hydrological process knowledge at the catchments scale from local terrestrial gravity. The implementation of a number of superconducting gravimeters in the framework of the Global Geodynamics Project offers the opportunity to investigate catchment-scale processes. Such a gravimeter is an advanced observation method to monitor water storage change (e.g. interception, snow, subsurface water) in the influence sphere of the instrument with a high temporal resolution..

One of these gravimeters is located at the Geodynamic Observatory in the Silberleite catchment (3.4 km^2) near Moxa, Germany. The catchment's subsurface consists predominately of slates, which are fractured at the top and intersected by faults. The slates are covered by a permeable weathering layer and a clayey soil occurs with a variable depth. The catchment has an undulating landscape, with occasionally steep slopes (up to 20˚). It is mainly covered with coniferous forest. In the downstream part of the valley where the observatory is located at the foothill of a steep slope, a mainly coarse valley fill occurs with a thickness of several meters. Observed streamflow at different locations show that the catchment quickly responds to rainfall after filling up

the subsurface stores.

Initial research results show that short-term gravity variation, which is corrected for a number of effects (e.g. polar motion, earth tides) is highly correlated with medium and high rainfall reflecting quick redistribution of water near the gravimeter. Simulated gravity variation (integrated over the influence sphere) with a rainfall-runoff model, in which the spatial and temporal distributed water storage is converted to gravity, agrees well with observed gravity variation except for periods that groundwater storage change affects gravity. Observed gravity in the Silberleite catchment is predominantly affected by groundwater storage changes in the valley fill. Infiltration experiments at the steep slope above the gravimeter and at the gentle slope opposite of the gravimeter illustrate that piezometers in the valley fill respond rather quickly to groundwater flow mainly through the weathering layer and fractured slates (shallow subsurface flow). Streamflow gauges in the longitudinal profile of the Silberleite show that groundwater storage in the valley fill changes due to infiltration from the stream just upstream of the gravimeter. Additionally, saturated groundwater flow modelling demonstrates that groundwater storage locally changes (development of injection cones) because of the outflow from the rain pipes draining the roof over the observatory. It is anticipated that the observed varying gravity will also rather well reflect groundwater storage change if the different groundwater flow processes (e.g. infiltration from the stream, shallow subsurface flow from the different slopes) each with its own time constant are accounted for.